The Art of Simplified Models

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Corfu, September 9, 2013

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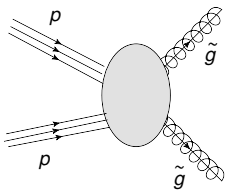
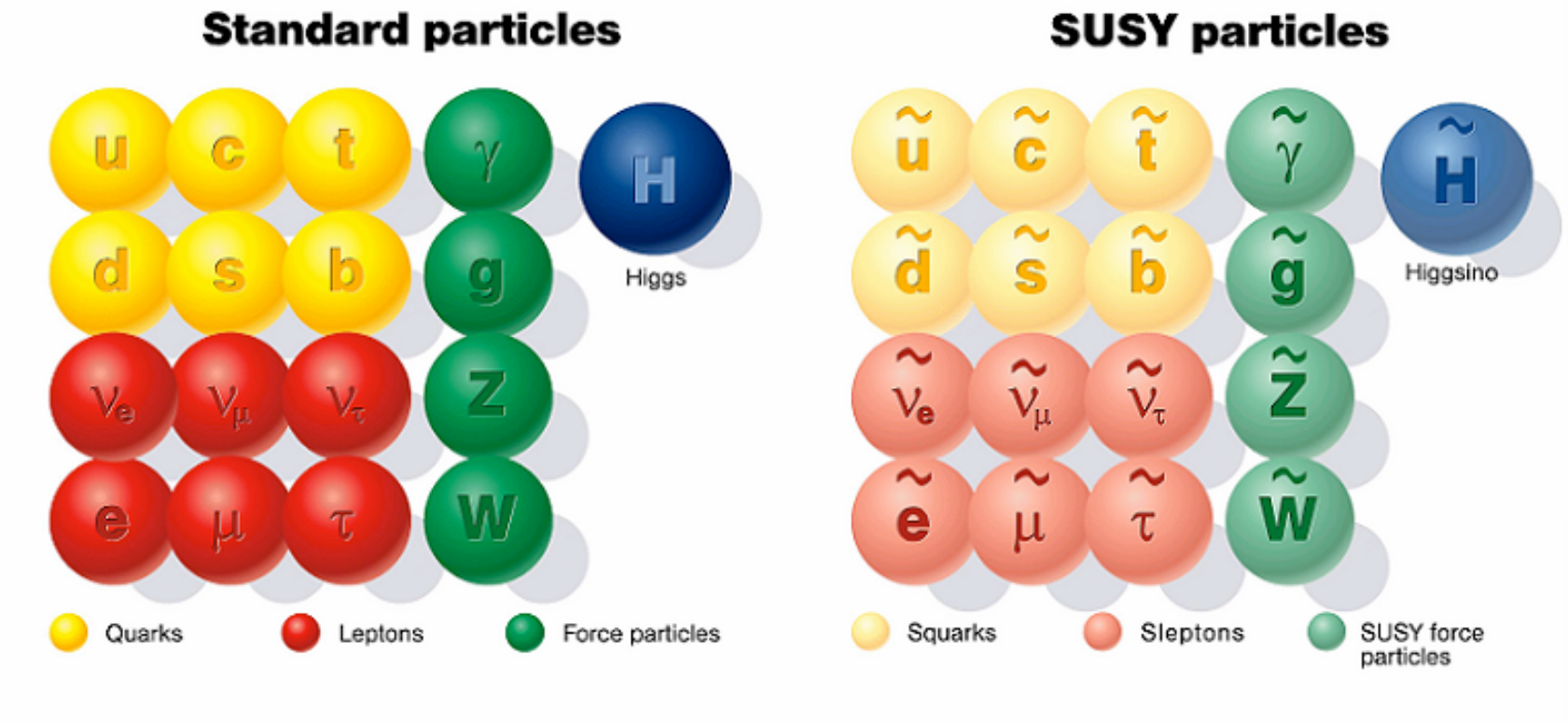
With thanks to: Christian Autermann (RWTH Aachen)
Wolfgang Waltenberger (HEPHY Vienna)



What is supersymmetry (SUSY)?

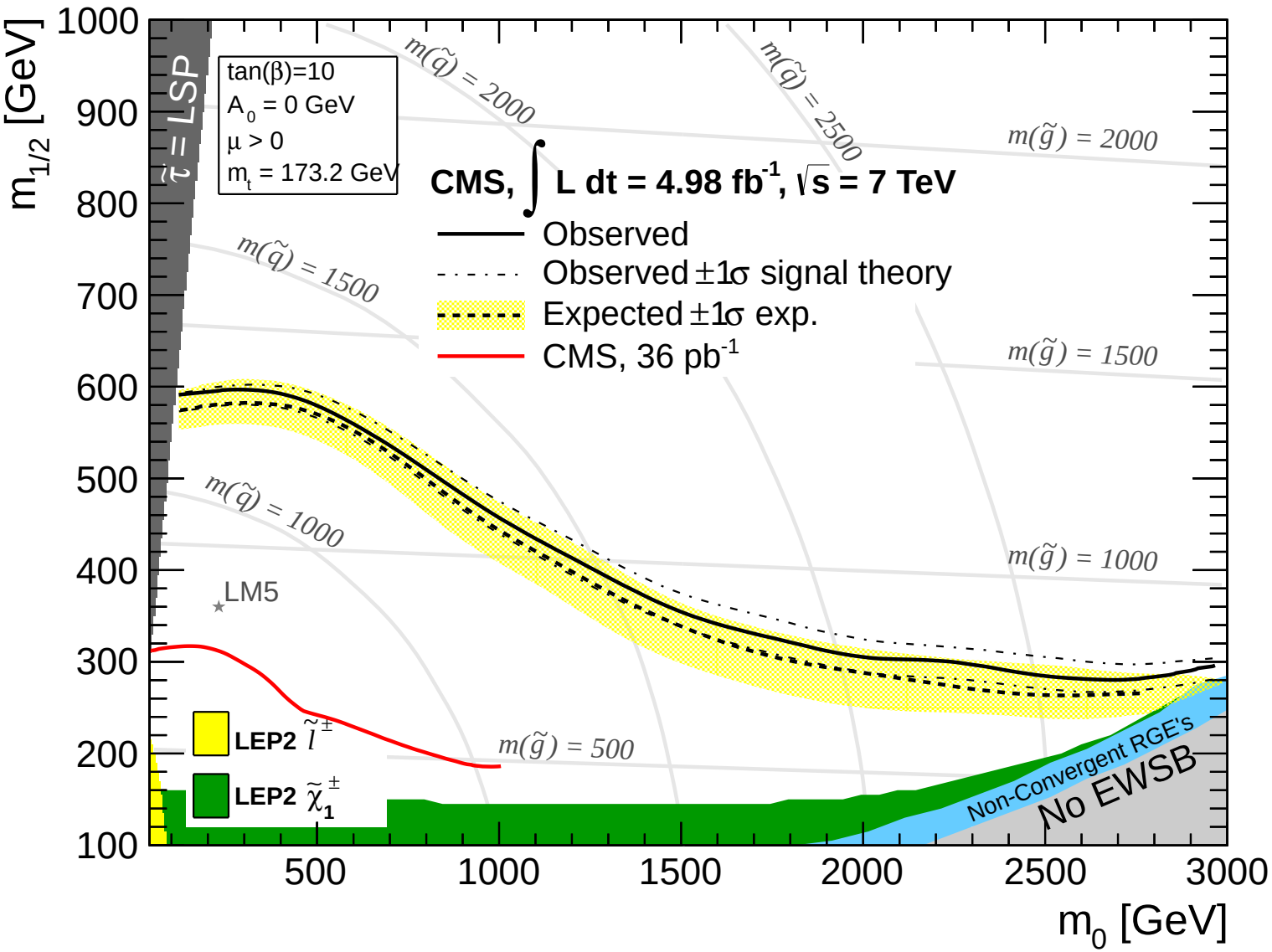


constrained Minimal Supersymmetric Standard Model (CMSSM)

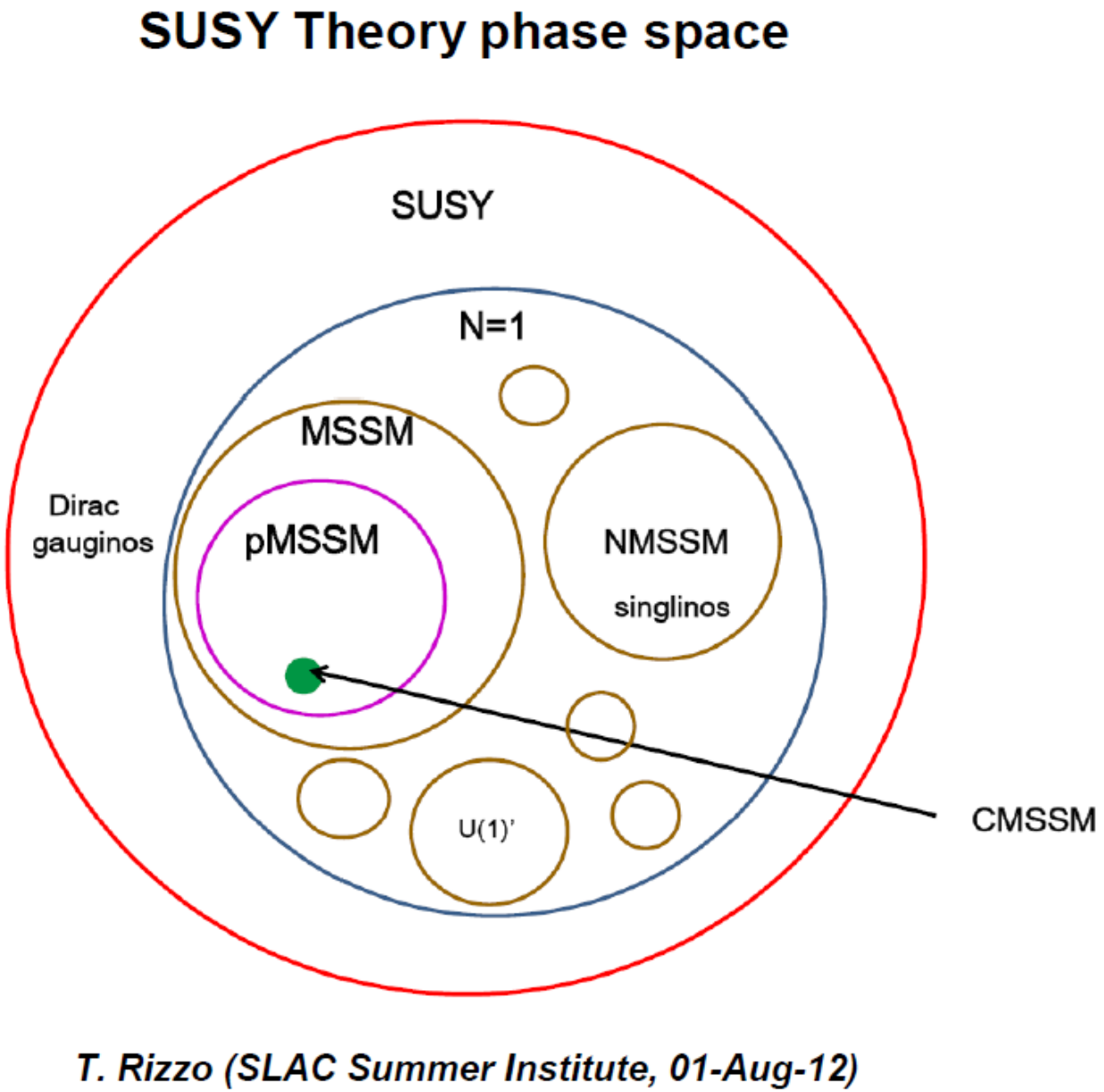
m_0, $m_{1/2}$ [, $A_0 = 0$, $\tan\beta = 10$, $\mathrm{sign}(\mu) = +1$]

Direct: Exclusion from CMS for CMSSM

arXiv:1207.1898

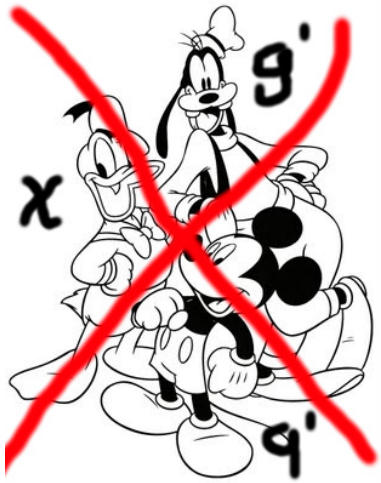


CMSSM: Scope


SUSY Theory phase space
SUSY
N=1
MSSM
pMSSM
Dirac
gauginos
NMSSM
singlinos
U(1)'
CMSSM
T. Rizzo (SLAC Summer Institute, 01-Aug-12)

SUSY Phenomenology: simplify

$\rightarrow$

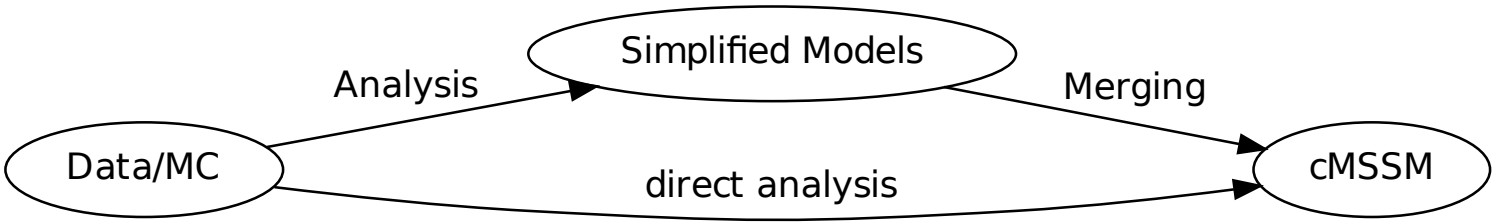


Add to Standard Model

$$\mathrm{SM} + \tilde{g} + \tilde{\chi}_1^0 + \tilde{q}_L$$

SUSY particles (fixed spin)

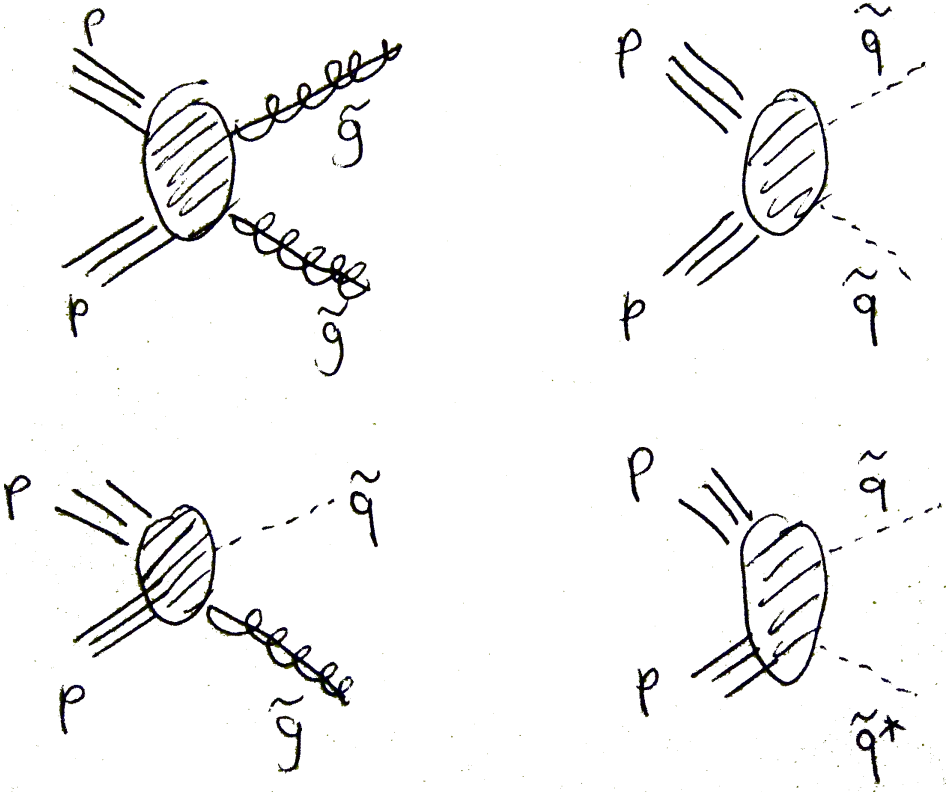
Alternative Approach: Simplified Models



- Idea: do analysis once and use it for different (SUSY) models
- Can we get similiar exclusions from Simplified Models?

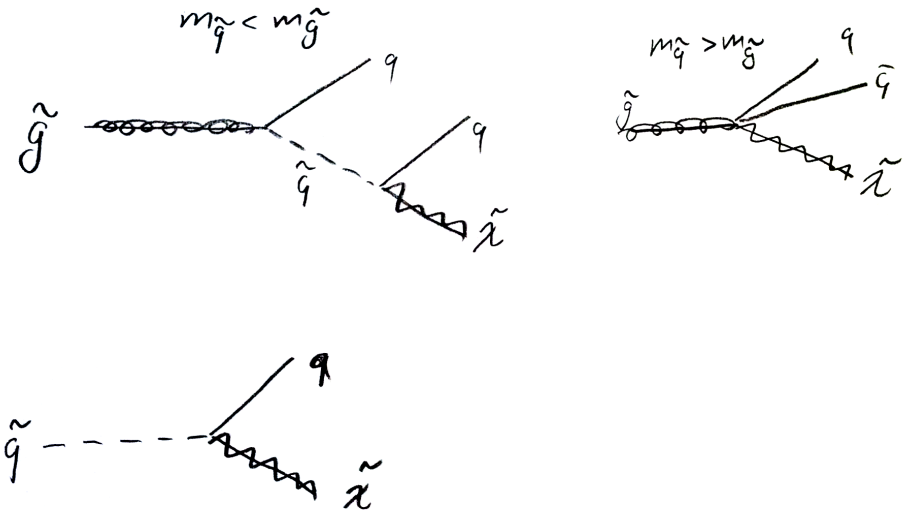
Simplified Models and an all-hadronic analysis (jets + missing energy)

Production modes:



$\tilde{g}\tilde{g}$, $\tilde{q}\tilde{g}$, $\tilde{q}\tilde{q}$, $\tilde{q}\tilde{q}^*$

Decay modes:



free parameters: $m_{\tilde{g}}, m_{\tilde{q}}, m_{\tilde{\chi}}$

Simplified model example:

$S_1 = pp \to \tilde{q}\tilde{q}, \quad \tilde{q} \to q\chi_1^0$

How to exclude:

Upper limit

$$\sigma^{\mathrm{ul}} = \frac{2\Delta B}{(A\varepsilon)L}$$

SUSY event yield:

$$N = N_{S_1} + N_{S_2} + N_R$$

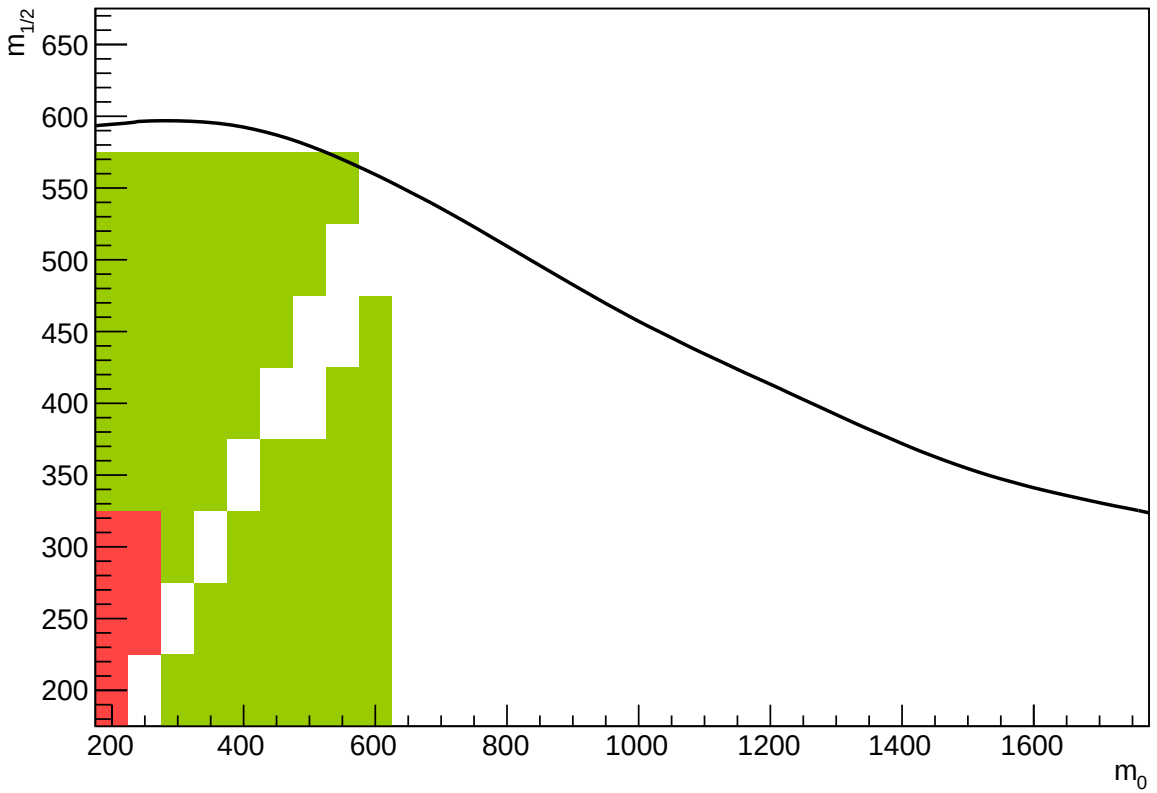
$$\Rightarrow (A\varepsilon)_{\mathrm{SUSY}}\sigma_{\mathrm{SUSY}} = (A\varepsilon)_{S_1}\sigma_{S_1} + (A\varepsilon)_{S_2}\sigma_{S_2} + (A\varepsilon)_R\sigma_R$$

$\sigma_{S_1}, \sigma_{S_2} \equiv$ cross section $\times$ branching ratios; R = 'rest' of SUSY.

Weaker limit

$$\Rightarrow (A\varepsilon)_{\mathrm{SUSY}} \geq \frac{(A\varepsilon)_{S_1}\sigma_{S_1} + (A\varepsilon)_{S_2}\sigma_{S_2}}{\sigma_{\mathrm{SUSY}}} \equiv (A\varepsilon)_{\mathrm{SMS}}$$

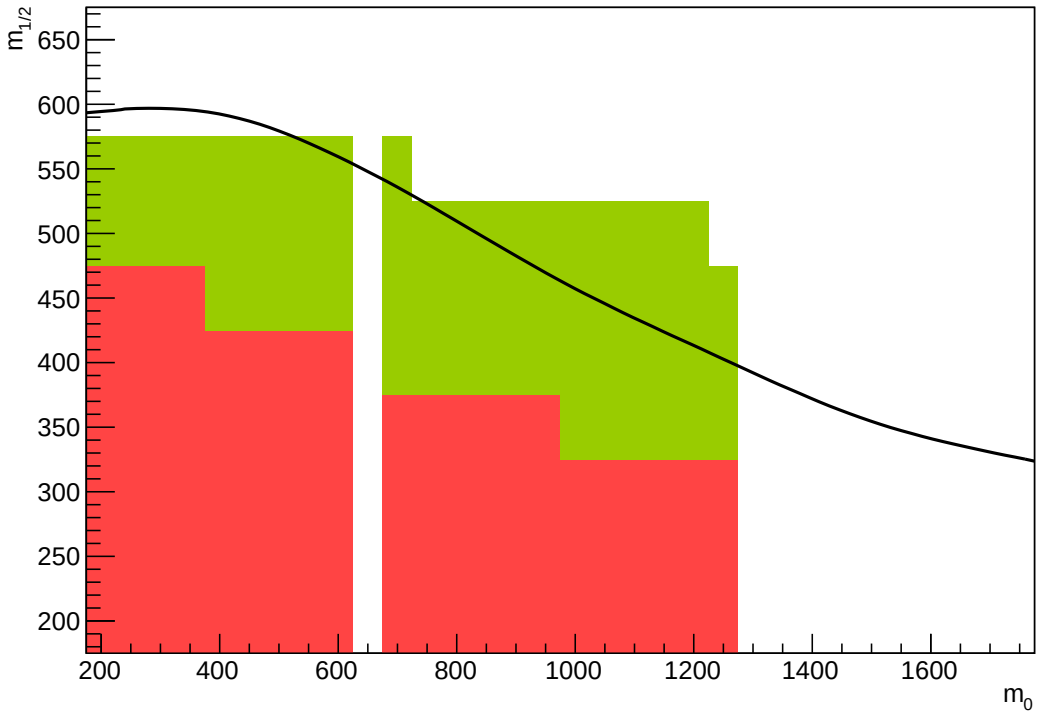
Conservative Exclusion (preliminary!)



- **black line**: CMSSM exclusion (combination of 14 H_T bins, CLs)
- **red**: excluded with Simplified Models ($H_T > 1400$ GeV, $\not{H}_T > 200$ GeV, CLs)
- **green**: not excluded

Exclusion (preliminary!)

- Assumption: We can use Simplified Model $A\varepsilon$ for every $\tilde{q}/\tilde{g} \rightarrow$ jets $\tilde{\chi}$.
- Possible for CMSSM - but we need a CMSSM analysis to show that the assumption is sensible.

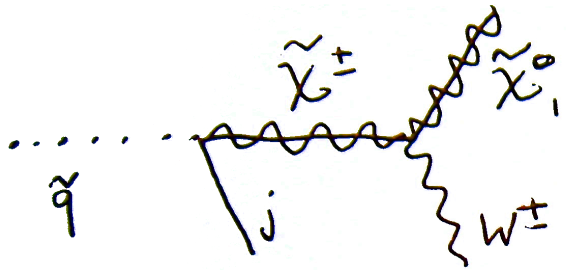


$H_T > 1400$ GeV,
$\not{H}_T > 200$ GeV, CLs

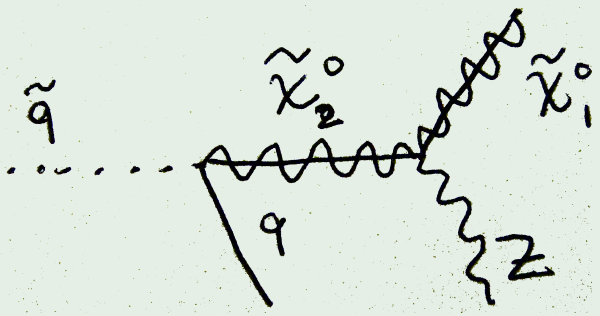
Closure?

Problems

- Other decays may be underrepresented, e.g.

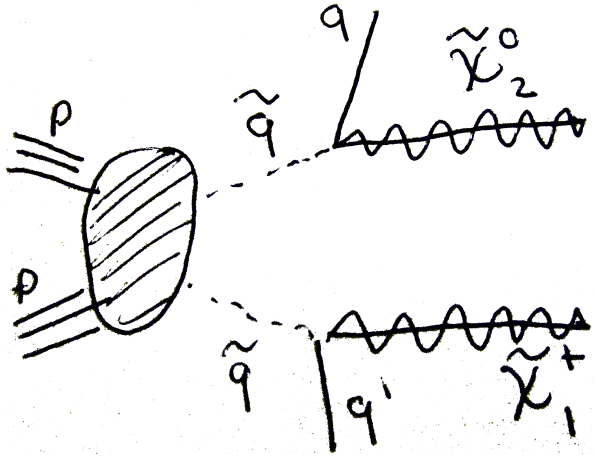


Investigate $A \times \varepsilon$ for other models



Careful, however:

- We do not want to introduce new parameters
- Mixtures of Simplified Models could be important, e.g.



We would need *branching ratios* as new parameter!

Summary and Outlook

Universal Extra Dimensions $\stackrel{?}{:=}$

Simplified model exclusion for CMSSM

- Assumption: results can be scaled with $\sigma \times$br
- Closure for CMSSM

Further work

- Does it work for other SUSY models?
- What about other models? Universal Extra Dimensions?